Energy efficiency research and regulation in Estonia

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Presentation outline

- Estonian EP requirements:
  - nZEB
  - min. reqs. for new buildings
  - min. reqs. for major renovations

- Renovation KredEx grant scheme requirements
  - Energy performance
  - Ventilation requirements
  - Thermal insulation and thermal bridges
  - Examples of ventilation solutions

- Some examples of research topics
Brief history of the primary (source) energy based regulation

- First Estonian primary energy regulation based on EPBD was prepared in 2007 (in force Jan 1, 2008)
- Estonian Cost Optimal calculations were conducted as a financial calculation in 2011
  - Cost optimal calculations included nZEB solutions
  - The results provided an input to the revision of energy performance minimum requirements in 2012

- Cost optimal energy performance minimum requirements, low energy and nZEB requirements and are now implemented into regulation and apply from Jan 9, 2013.
Information sheet of the calculated EPC for new building – class A apartment building
Estonian system boundaries

- One of the most advanced energy frames with full utilization of on site renewable and exported energy
- Follows REHVA nZEB definition and system boundaries
- Lighting & Appliances included, i.e. calculated ≈ measured
US DOE Site Boundary for ZEB Accounting

- **Launched Sept 15, 2015**

  [Link to DOE release](http://energy.gov/eere/buildings/articles/doe-releases-common-definition-zero-energy-buildings-campuses-and)

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**Notes**

1. The dashed lines represent energy transfer within the boundary.
2. The solid lines represent energy transfer entering/leaving the boundary used for zero energy accounting.
Estonian regulation

- **EP Compliance assessment:**
  - For all buildings equipped with cooling, energy performance calculation shall be based on **dynamic building simulation**
  - Requirements are specified for **simulation tools**, which refer to relevant European, ISO, ASHRAE or CIBSE standards, IEA BESTEST or other equivalent generally accepted method.
  - For residential buildings without cooling, monthly energy calculation methods may be also used.
  - An exception is for detached houses, which have an alternative compliance assessment method based on tabulated specific heat loss values

- **Summer thermal comfort:**
  - If no cooling is installed, a **dynamic temperature simulation** in critical rooms is required in order to comply with summer temperature requirements (25°C + 100 °Ch in non-residential and 27°C + 150 °Ch in residential buildings during three summer months simulated with TRY)
  - An exception is for detached house, there the compliance may be alternatively shown with tabulated values for solar protection, window sizes and window airing
Minimum requirements: Detached house (1/2013 data)

- Recalculation from primary energy to delivered energy needed, which can be compared in all countries.
- 150 m² detached house considered.
- Degree-day correction (base 17°C) to Copenhagen, energy use for hot water heating 25 kWh/(m²a).
- The figure shows maximum allowed delivered energy without household electricity (i.e. delivered energy to heating, hot water and ventilation systems) in each country for fossil fuel or electrical heating.

Source: Kurnitski J. et al. Comparison of energy performance requirements in selected countries. CLIMA 2013.
Apartment and office buildings with district heating

- Maximum allowed delivered energy for heating, hot water and ventilation systems in apartment buildings and for office buildings (lighting included) with district heating.
MTM No 55: 2012 – Minimum requirements for energy performance

- Minimum requirements are given for 9 building types, for new buildings and for major renovation
- nZEB and low energy building requirements officially given together with cost optimal minimum requirements

Primary energy factors:
- Electricity 2.0, Fossil fuels 1.0, District heat 0.9 and Renewable fuels 0.75

<table>
<thead>
<tr>
<th>EPC class</th>
<th>nZEB [kWh/m²y]</th>
<th>Low energy [kWh/m²y]</th>
<th>Min. req. NEW [kWh/m²y]</th>
<th>Min. req. Major REN [kWh/m²y]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detached houses</td>
<td>50 (0&lt;sup&gt;a&lt;/sup&gt;)</td>
<td>120</td>
<td>160 (110&lt;sup&gt;a&lt;/sup&gt;)</td>
<td>210</td>
</tr>
<tr>
<td>Apartment buildings</td>
<td>100 (41&lt;sup&gt;a&lt;/sup&gt;)</td>
<td>120</td>
<td>150 (101&lt;sup&gt;a&lt;/sup&gt;)</td>
<td>180</td>
</tr>
<tr>
<td>Office buildings</td>
<td>100 (62&lt;sup&gt;b&lt;/sup&gt;)</td>
<td>130</td>
<td>160 (128&lt;sup&gt;b&lt;/sup&gt;)</td>
<td>210</td>
</tr>
</tbody>
</table>

<sup>a</sup> without lighting and appliances, <sup>b</sup> without appliances
# MTM No 55: 2012 – Full set of EP requirements

<table>
<thead>
<tr>
<th>Building category</th>
<th>nZEB A kWh/(m² y)</th>
<th>Low energy B kWh/(m² y)</th>
<th>Minimum req. C kWh/(m² y)</th>
<th>Minimum req. NEW (cost opt.) D kWh/(m² y)</th>
<th>Minimum req. Major REN D kWh/(m² y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detached houses</td>
<td>50</td>
<td>120</td>
<td>160</td>
<td></td>
<td>210</td>
</tr>
<tr>
<td>Apartment buildings</td>
<td>100</td>
<td>120</td>
<td>150</td>
<td></td>
<td>180</td>
</tr>
<tr>
<td>Office buildings</td>
<td>100</td>
<td>130</td>
<td>160</td>
<td></td>
<td>210</td>
</tr>
<tr>
<td>Hotels and restaurants</td>
<td>130</td>
<td>160</td>
<td>210</td>
<td></td>
<td>270</td>
</tr>
<tr>
<td>Public buildings (theatres, sport halls, museums etc.)</td>
<td>120</td>
<td>150</td>
<td>200</td>
<td></td>
<td>250</td>
</tr>
<tr>
<td>Shopping malls</td>
<td>130</td>
<td>160</td>
<td>230</td>
<td></td>
<td>280</td>
</tr>
<tr>
<td>Schools</td>
<td>90</td>
<td>120</td>
<td>160</td>
<td></td>
<td>200</td>
</tr>
<tr>
<td>Day care centres</td>
<td>100</td>
<td>140</td>
<td>190</td>
<td></td>
<td>240</td>
</tr>
<tr>
<td>Hospitals</td>
<td>270</td>
<td>300</td>
<td>380</td>
<td></td>
<td>460</td>
</tr>
</tbody>
</table>
Requirements for renovation

- Minimum requirements of major renovation (EPC class D) and replacement of technical systems

- Additional, more strict technical requirements of KredEx renovation grants
The Estonian KredEx renovation grant programme for apartment buildings

Jarek Kurnitski
February 26, WSED 2016
Grants 15%, 25% and 40%

2010-2014
35% 25% 15%

2015-2020
40% 25% 15%
+ more strict ventilation and other requirements

nZEB
Example: Sõpruse pst 202, Tallinn

- 11 375 m² (162 ap. 2012-2013)
- Investment € 2 062 000, 181 €/m²
- Grant 35% € 721 600, 63 €/m²
- Credit € 1 340 000, 20 years
- Measured annual savings 63%, ~500 MWh
Example: Sõpruse pst 202, Tallinn

- External insulation of facade + roof insulation
- Triple windows (+moved to the insulation layer)
- Heating system: exhaust air heat pump + district heating
- Ventilation system: ventilation radiators and old stacks for extract
Why renovation grants?

Estonian studies report highly significant economic benefits from renovation:

• quantified tax return of 32% of renovation total cost
• job creation of 18 jobs in a year per 1 M€ renovation cost

KredEx renovation grant reqs

• 15% financial support – EPC class E
• 25% financial support – EPC class D (EP ≤ 180 kWh/(m²·y))
• 40% financial support – EPC class C (EP ≤ 150 kWh/(m²·y))
• + some additional technical requirements especially for ventilation and insulation

• no nZEB (EPC class A) ambition (less strict nZEB not defined for renovation in Estonia)
• 40% grant will keep the monthly payment for the occupant roughly at the same level before and after the renovation – renovated building, improved indoor climate and real estate value being a bonus
• 25% grant slightly less cost effective because of tight ventilation requirements
Breakdown of 40% renovation grant EPC class C requirement (150 kWh/m²y)

- Apartment building with gas heating (for district heat slightly more heating is accepted because of primary energy factor of 0.9)
- Applies both for renovation with 40% grant as well as for new building

<table>
<thead>
<tr>
<th></th>
<th>Energy need, kWh/m²</th>
<th>Delivered energy, kWh/m²</th>
<th>Primary en. factor, -</th>
<th>Primary energy, kWh/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space heating</td>
<td>22</td>
<td>25.7</td>
<td>1.0</td>
<td>25.7</td>
</tr>
<tr>
<td>Vent. heating</td>
<td>14</td>
<td>14.7</td>
<td>1.0</td>
<td>14.7</td>
</tr>
<tr>
<td>DHW</td>
<td>30</td>
<td>31.6</td>
<td>1.0</td>
<td>31.6</td>
</tr>
<tr>
<td>HVAC aux.</td>
<td>9.5</td>
<td>9.5</td>
<td>2.0</td>
<td>19.0</td>
</tr>
<tr>
<td>Lighting</td>
<td>7</td>
<td>7</td>
<td>2.0</td>
<td>14.0</td>
</tr>
<tr>
<td>Appliances</td>
<td>22.5</td>
<td>22.5</td>
<td>2.0</td>
<td>45.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>105</strong></td>
<td><strong>111</strong></td>
<td></td>
<td><strong>150</strong></td>
</tr>
</tbody>
</table>

- Energy needs of DHW, lighting and appliances are regulated values
- Delivered energy of DHW depends on the system (efficiencies etc., in this case no solar collectors or heat pumps are considered)
KredEx ventilation requirements

25% renovation grant:

• Continuous an average ventilation (for total apartment) 0.5 l/h;
• Supply or intake air flow rates to be at least **10 l/s in bedrooms and living rooms** at sound power level no more than 25 dB(A);
• Extract air flow rates at least **10 l/s WC, 15 l/s bathroom and 8 l/s kitchen** (**10 l/s in bathroom and 6 l/s in kitchen in one room flats**);
• Preheating of intake air generally required (ventilation radiators recommended, but intake air vents accepted);
• **Heat recovery is NOT required** (but depending on the building, EPC class D might be difficult to achieve without HR)
• (for the heating system, balancing and installation of thermostats is required)
KredEx ventilation requirements

Additional requirements for 40% renovation grant:

• (The same airflow rates as in the case of 25% grant)
• Mechanical supply and exhaust ventilation with heat recovery OR exhaust air heat pump with ventilation radiators required

• It is considered that ventilation radiators with filters and heating of intake air will provide similar good indoor climate as heat recovery ventilation
• EPC class C requirement is easier with heat recovery ventilation, exhaust air heat pump might need additional measures depending in the building
# Sizing of ventilation in typical apartments

Ventilation air flow rates according to requirements:

<table>
<thead>
<tr>
<th></th>
<th>Floor area, m²</th>
<th>Extract airflow rate, l/s</th>
<th>Supply airflow rate, l/s</th>
<th>Air change l/s m²</th>
<th>1/h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>WC</td>
<td>Bathr.</td>
<td>Kitchen</td>
<td>Total</td>
</tr>
<tr>
<td>Single room</td>
<td>35</td>
<td>10</td>
<td>6</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>1 bedroom</td>
<td>55</td>
<td>15</td>
<td>8</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>2 bedrooms</td>
<td>70</td>
<td>10</td>
<td>15</td>
<td>8</td>
<td>33</td>
</tr>
<tr>
<td>3 bedrooms</td>
<td>80</td>
<td>10</td>
<td>15</td>
<td>12</td>
<td>33</td>
</tr>
</tbody>
</table>

To balance the ventilation, supply airflow rates are to increased in small apartments and extract airflow rates in large apartments:

<table>
<thead>
<tr>
<th></th>
<th>Floor area, m²</th>
<th>Extract airflow rate, l/s</th>
<th>Supply airflow rate, l/s</th>
<th>Air change l/s m²</th>
<th>1/h</th>
</tr>
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<tr>
<td></td>
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</tr>
<tr>
<td>3 bedrooms</td>
<td>80</td>
<td>12</td>
<td>16</td>
<td>12</td>
<td>40</td>
</tr>
</tbody>
</table>
## KredEx Insulation requirements

### U-value and thermal bridge requirements

<table>
<thead>
<tr>
<th></th>
<th>25% grant</th>
<th>40% grant</th>
</tr>
</thead>
<tbody>
<tr>
<td>External wall (opaque), W/(m²K)</td>
<td>0.25</td>
<td>0.22</td>
</tr>
<tr>
<td>Windows (tot value), W/(m²K)</td>
<td>1.1</td>
<td>1.1</td>
</tr>
<tr>
<td>Roof, W/(m²K)</td>
<td>0.15</td>
<td>0.12</td>
</tr>
<tr>
<td>Linear thermal bridge (window-wall) W/mK</td>
<td>-</td>
<td>0.05</td>
</tr>
</tbody>
</table>

In the case of 40% grant, windows are to be replaced and moved to the insulation layer in order to comply with thermal bridge requirement.
Loomulik ventilatsioon:
– Ebapiisav õhuvahetus (peale akende vahetust)
– Puudulik siseõhu kvaliteet
– Kontrollimatu toimivus
– Suur energiakulu
– Puhub peale (värske õhu klappidega)
– Liigniiskus
Room ventilation HR units

- Additional exhaust ventilation needed from toilets, bathrooms and kitchens destroying the heat recovery – room ventilation principle is not suitable for residential ventilation
- Most of equipment too noisy especially in bedrooms
- If small fans, may operate as intake vents because of stack effect – no heat recovery at all
- Defrost protection often not working in a cold climate
Mechanical exhaust, exhaust air heat pump and ventilation radiator

- Heat recovery of: 60-70% (to domestic hot water and return of heating)
- Intake air: ventilation radiators in living rooms and bedrooms
- Extract air: kitchen, WC, bathroom
- Heat pumps: rooftops or in the basement
- Extract ductwork: tightened stacks or new
Achievement of EPC class C may need some additional measures (better insulation, PV or heat recovery from waste water).

Utilization of existing stacks – need to be cleaned and tightened – airflow rate measurements protocols are required.
Mechanical supply and extract heat recovery ventilation – rooftop and facade installation – no ductwork in apartments
2015 innovation – economic facade installation of HRV ventilation
Summary

• Lessons learnt 2010-2014 period – poor ventilation sometimes resulting in moldy apartments the most significant problem

• 2015-2020 grant system requires HRV ventilation (and commissioning protocols for verification) and moving windows to insulation level in the case of 40% grant as major changes

• Both changes were first seen as „fully impossible“ by stakeholders, but 6 months experience reveals that economic solutions are found

• Model renovation solutions – KredEx renovation manual is prepared – designers can copy and customize the model solutions

• First 6 months show good number of applications for 40% grant
Selected examples of research topics
TTÜ liginullenergia testhoone

- Tuleviku hoonete välispiirete, tehnosüsteemide ja taastuvennergia lahendused
- Ligi 700 000 € maksnad testhoone ehitamist toetas Riigi Kinnisvara AS
Energy pile applications

Heat supply
- Ground source heat pump
- Energy piles
- Hot tank
- Top-up heater
- Solar collector for loading
- Heat exchanger for loading
- Free cooling loop
- Extract air heat exchanger

Cooling supply
- Cold tank
- Free cooling heat exchanger
- Chiller

Room units
- Ceiling panels for heating and cooling
- Heat recovery air handling unit
Vertical spiral collectors
State Real Estate Twin-Towers building, Tallinn – facade and energy analyses of a low energy building

<table>
<thead>
<tr>
<th>Window to wall ratio, %</th>
<th>25</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td>$U_{\text{window}}$, W/(m$^2$ K)</td>
<td>0.6</td>
<td>0.6</td>
</tr>
<tr>
<td>LT, %, single/double facade</td>
<td>71/62</td>
<td>71/62</td>
</tr>
<tr>
<td>g, -, single/double facade</td>
<td>0.49/0.42</td>
<td>0.49/0.42</td>
</tr>
<tr>
<td>$U_{\text{wall}}$, W/(m$^2$ K)</td>
<td>0.18</td>
<td>0.18</td>
</tr>
</tbody>
</table>

- 7 W/m$^2$ installed lighting, occupancy sensors and photocell controlled dimming
- Double facades with blinds in between + external solar shading for single facades
- Energy needs in the Figs (COPs, syst. efficiencies, energy carriers not considered)
- Primary energy / life cycle cost to be optimized
**Specification of cost effective facades – heating, cooling, electric lighting and daylight problem**

<table>
<thead>
<tr>
<th>Fassaadilahendus</th>
<th>Kirjeldus</th>
<th>Võtmenäitajad</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Energiatõhususe ja sisekliima seisukohast majanduslikult tasuvaim lahendus:</strong> kolmekordne pakett ja 200 mm soojustus</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Aknad:  
- Kolmekordne kirgas pakett  
- Akna osakaal välisseinast: 23,9 %  
- Klaaspaketi soojusläbivus: 0,54 W/(m²-K)  
- Tättegaas: 90% argoon  
- Päikesefaktor g: 0,49  
- Valgusläbivus τvis: 0,70  
- Akna hind: 122 €/m² |  | Investeering: 95,7 €/m² |
|  |  | Energiatõhususarv: 109,9 kWh/m² |
|  |  | Aastane kulu energiale: 8,50 €/m² |
|  | Välissein:  
- Mineraalvilla paksus: 200 mm  
- Soojusläbivus: 0,16 W/(m²-K)  
- Hind: 180 €/m² |  | 20 aasta nüüdisväärtus: 295,7 €/m² |
| **B. Järgmine mõistlik lahendus:** neljakordne klaaspakett ja 250 mm soojustus (põhjafassaadi puhul osakaal 60%, vt joonis C) |  |  |
| Aknad:  
- Neljakordne kirgas pakett  
- Akna osakaal välisseinast: 37,5 % ja põhjas 60%  
- Klaaspaketi soojusläbivus: 0,32 W/(m²-K)  
- Tättegaas: 90% krypton  
- Päikesefaktor g: 0,36  
- Valgusläbivus τvis: 0,63  
- Akna hind: 177 €/m² ja põhjafassaadil 145 €/m² |  | Investeering: 107,8 €/m² |
|  |  | Energiatõhususarv: 109,1 kWh/m² |
|  |  | Aastane kulu energiale: 8,19 €/m² |
|  | Välissein:  
- Mineraalvilla paksus: 250 mm  
- Soojusläbivus: 0,13 W/(m²-K)  
- Hind: 228 €/m² |  | 20 aasta nüüdisväärtus: 300,5 €/m² |
| **C. Energiatõhusaim fassaadilahendus:** viiekordne klaaspakett ja 390 mm soojustus. |  |  |
| Aknad:  
- Viiekordne kirgas pakett  
- Akna osakaal välisseinast: 60%  
- Klaaspaketi soojusläbivus: 0,21 W/(m²-K)  
- Tättegaas: 90% krypton  
- Päikesefaktor g: 0,24  
- Valgusläbivus τvis: 0,56  
- Akna hind: 231 €/m² |  | Investeering: 160,5 €/m² |
|  |  | Energiatõhususarv: 103,4 kWh/m² |
|  |  | Aastane kulu energiale: 8,03 €/m² |
|  | Välissein:  
- Mineraalvilla paksus: 390 mm  
- Soojusläbivus: 0,093 W/(m²-K)  
- Hind: 363 €/m² |  | 20 aasta nüüdisväärtus: 349,4 €/m² |
Välisvarjestuse ja valgustuse juhtimise võimalused

- Välised ribakardinad on varustatud 1-2 mootorajamiga ülesalla tömbamiseks ning ribide nurga muutmiseks (1)
- Lisaks küttele ja jahutusele on oluline **valgustuse automaatne juhtimine vastavalt päevavavalgusele ja inimeste kohalolekule** (2)
- Ruumi kasutaja saab muuta seadesuuruseid juhtpuldilt, kus asub ka temperatuuriandur (3)
- Välisfassaadil lisaks nt tuulemõõtjad tormi puhuks
Milline on optimaalne juhtimispõhimõte?

- Simulatsioonid programmiga IDA ICE 4.5
- Oluline on juhtida varjestust vastavalt sisetingimustele
- Valgus + küte + vaade vs. jahutus???
First nZEB office building in Estonia – Rakver Smart Building competence centre

Research questions:
- nZEB office building without space heating system?
- Feasibility of double skin facades
- Heated and unheated atrium spaces
- Functionality specification for test environments in the building
Overheating prevention requirement in dwellings – temperature excess $\leq 150 \, ^\circ\text{C} \text{h}$ (degree-hours)
Selection of dwellings with highest risk of overheating
Example from ESTONIA: Assessment of overheating

Overall building results:
17 out of 25 (68%) did not comply with the regulation
Deep integrated renovation

The phenomena of deep integrated renovation:

- Investment cost of renovation of 160 €/m² equals to annual repair fund collection during 20 years of 31.2 €/m² (19% of renovation investment) for roof etc. small repairs, i.e. the total cost is the same

- Development of technical requirements for Estonian KredEx renovation grants
Additional insulation can worsen the thermal bridge
Some examples of thermal bridge values

- Additional insulation may increase thermal bridge value from original 0.13 to 0.35 W/mK if windows are not moved to the insulation layer:

  \[ f_{\text{Rsi}} = 0.73; \ \Psi = 0.13 \text{ W/(m·K)} \]
  \[ f_{\text{Rsi}} = 0.78; \ \Psi = 0.35 \text{ W/(m·K)} \]

  \[ f_{\text{Rsi}} = 0.86; \ \Psi = 0.20 \text{ W/(m·K)} \]

- Moving the windows will result in very low thermal bridges of about 0.02-0.03 W/mK:

  \[ f_{\text{Rsi}} = 0.90; \ \Psi = 0.02 \text{ W/(m·K)} \]
  \[ f_{\text{Rsi}} = 0.88; \ \Psi = 0.03 \text{ W/(m·K)} \]
An example of renovated building

- Heat loss through the insulated wall w/o the thermal bridge: 14 MWh/y
- Heat loss through the window-wall thermal bridge: 19 MWh/y
ZEB as a part of energy system

**Energy system level:**
- Primary energy
- CO₂ emissions
- Embodied energy
- Peak power

**District level:**
- Load profiles
- Nearby generation
- Energy storage

**Single building level:**
- Building performance
- On-site generation
- Energy storage

- WP6: Interaction of ZEB & energy system
- WP5: Power conversion
- WP4: RES & load management
- WP1: HVAC & passive measures
- WP2: Building envelope
- WP3: Embodied & recourses
REHVA nZEB Task Force

- TF prepared nZEB technical definition and set of system boundaries for primary energy indicator and RER calculation in 2011
- in 2013 it was revised in cooperation with CEN, resulting in REHVA Report No:4
- TF is following nZEB technical, regulatory and policy progress
- Latest, ongoing analyses on RE contribution and RER indicator based on data from 8 nZEB office and school buildings across the EU
### nZEB Task Force latest buildings (5-8 in the Table)

<table>
<thead>
<tr>
<th>Building Name</th>
<th>Country</th>
<th>Construction Year</th>
<th>Floor Area (m²)</th>
<th>Extra nZEB Cost (€/m²)</th>
<th>Cost Estimate</th>
<th>General Description</th>
<th>Energy Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DSK-II school, Haarlem, the Netherlands</strong></td>
<td></td>
<td>2014</td>
<td>3,900</td>
<td>250</td>
<td>estimated</td>
<td>Primary school with zero energy consumption, meaning the total amount of energy used for the building itself on an annual basis is roughly equal to the amount of renewable energy produced on site.</td>
<td><strong>Net-zero energy building</strong> without accounting small power equipment loads, achieved with large on-site PV, heat pumps and energy wells.</td>
</tr>
<tr>
<td><strong>Väla Gård office building, Sweden</strong></td>
<td></td>
<td>2013</td>
<td>1,750</td>
<td>230</td>
<td>estimated</td>
<td>Skanska head office, Nordea office nZEB building, energy consumption 55% less than code requirement, building demonstrates low speed ventilation and Skanska Deep Green Cooling, a ground cooling system without heat pump or chiller. Triple Leed Platinum.</td>
<td><strong>Nearly zero energy building</strong> if the share of wind farm is not accounted.</td>
</tr>
<tr>
<td><strong>Entré Lindhagen office building, Sweden</strong></td>
<td></td>
<td>2014</td>
<td>65,000</td>
<td>55</td>
<td>estimated</td>
<td>Skanska office in Helsingborg. A nZEB office building, energy consumption is nearly zero or plus including tenant power over the year. LEED certified Platinum.</td>
<td><strong>Net zero energy building</strong> (small power equipment loads accounted) or <strong>plus energy building</strong> w/o small power, achieved with extensive on-site PV, ground source heat pump and boreholes.</td>
</tr>
<tr>
<td><strong>Rakvere Smart Building Competence Centre office building, Estonia</strong></td>
<td></td>
<td>2014-2015</td>
<td>2,170</td>
<td>200-300</td>
<td>estimated</td>
<td>Estonian first nZEB office building, primary energy consumption 60% less than code requirement, building demonstrates smart building automation systems.</td>
<td><strong>Nearly zero energy building</strong> (small power equipment loads accounted), achieved with on-site PV, district heating and energy wells.</td>
</tr>
</tbody>
</table>
Delivered, on-site and nearby generated, and primary energy

<table>
<thead>
<tr>
<th>Component</th>
<th>FRA</th>
<th>SUI</th>
<th>NL1</th>
<th>FIN</th>
<th>NL2</th>
<th>SWE1</th>
<th>SWE2</th>
<th>EST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating</td>
<td>10.5</td>
<td>6.0</td>
<td>13.3</td>
<td>38.3</td>
<td>20.5</td>
<td>32.2</td>
<td>10.0</td>
<td>25.0</td>
</tr>
<tr>
<td>Cooling</td>
<td>2.4</td>
<td>6.7</td>
<td>3.3</td>
<td>0.3</td>
<td>3.2</td>
<td>1.3</td>
<td>0.5</td>
<td>2.0</td>
</tr>
<tr>
<td>Fans &amp; pumps</td>
<td>6.5</td>
<td>8.1</td>
<td>17.5</td>
<td>9.4</td>
<td>11.8</td>
<td>13.2</td>
<td>3.0</td>
<td>9.7</td>
</tr>
<tr>
<td>Lighting</td>
<td>3.7</td>
<td>16.3</td>
<td>21.1</td>
<td>12.5</td>
<td>12.5</td>
<td>16.5</td>
<td>12.6</td>
<td>11.3</td>
</tr>
<tr>
<td>Appliances</td>
<td>21.2</td>
<td>26.8</td>
<td>19.2</td>
<td>19.3</td>
<td>5.0</td>
<td>16.9</td>
<td>12.6</td>
<td>18.5</td>
</tr>
<tr>
<td>On site electricity</td>
<td>-15.6</td>
<td>-30.9</td>
<td>-73.8</td>
<td>-7.1</td>
<td>-36.5</td>
<td>-39.0</td>
<td>-19.6</td>
<td></td>
</tr>
<tr>
<td>Nearby electricity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-47.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BioCHP fuel</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>184</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exported heat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-50.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary energy</td>
<td>42</td>
<td>66</td>
<td>68</td>
<td>96</td>
<td>33</td>
<td>23</td>
<td>-1</td>
<td>61</td>
</tr>
</tbody>
</table>

Primary energy factors:

<table>
<thead>
<tr>
<th>Component</th>
<th>nren</th>
<th>ren</th>
<th>tot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biofuel</td>
<td>0.5</td>
<td>0.5</td>
<td>1.0</td>
</tr>
<tr>
<td>District heat</td>
<td>0.7</td>
<td>0.3</td>
<td>1.0</td>
</tr>
<tr>
<td>Electricity</td>
<td>2.0</td>
<td>0.2</td>
<td>2.2</td>
</tr>
</tbody>
</table>
RER indicator vs. primary energy

- Good (negative) correlation between primary energy and RER
- Not very technology dependent
- >100% RERp does not allow to draw conclusions on the grid load
Some outcomes

Input to European harmonization:

- Preparation of European nZEB technical definition for uniformed national implementation of EPBD – REHVA nZEB definition 2013
- Comparative analyses of Estonian and Nordic building codes regarding energy performance minimum requirements

Input to national regulation:

- Preparation of the Estonian regulation on minimum energy performance requirements and calculation methodology (revision of the minimum requirements, governmental act MTM No 55:2012 and a new act of calculation methodology MTM No 58:2012)
- Preparation of the indoor climate and ventilation regulation (ongoing, completely new regulation)
- Preparation of EP and ventilation technical requirements for KredEx renovation grant system MTM No 23:2015

Guidebooks for low energy and nZEB – technical solutions for scoping and conceptual design
Cost Optimal and Nearly Zero-Energy Buildings (nZEB)
Definitions, Calculation Principles and Case Studies

Jarek Kurnitski, Editor

REHVA nZEB technical definition and system boundaries for nearly zero energy buildings
2013 revision for uniformed national implementation of EPBD recast prepared in cooperation with European standardization organization CEN
Madal-ja liginullenergia-hooned

Büroohoone põhi lahendused eskiis ja eelprojektis

Jarek Kurnitski, Martin Thalfeldt, Aivar Uutar, Targo Kalamees, Hendrik Voll, Argo Rosin

SISEKLIIMA ÕPITULEMUS TÖÖVILJAKUS

TALLINNA TEHNIKAÜLIKOOL
TALLINN UNIVERSITY OF TECHNOLOGY

2015
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